

What is claimed is:

1           1. An apparatus which controls tilting of a tilt mirror,  
2   said apparatus comprising:  
3           a control signal producing unit which produces a control  
4   signal, for feed-forward controlling of the tilting of said  
5   mirror, based on a parameter that determines a target tilt  
6   angle of said tilt mirror;  
7           a digital filter that removes a resonance frequency  
8   component, which is caused by movement of said tilt mirror  
9   into a desired angle, in said control signal, which is produced  
10   by said control signal producing unit; and  
11          a square root calculating unit that performs digital  
12   square-root calculation so as to compensate for non-linearity  
13   of said control signal, from which said resonance frequency  
14   component has been removed.

1           2. An apparatus as set forth in claim 1, wherein said  
2   control signal producing unit includes:  
3           a parameter input unit which inputs said parameter as  
4   said target tilt angle and driving property information of  
5   said tilt mirror; and  
6           an arithmetic operation unit which obtains said control  
7   signal by arithmetic operation based on said target tilt  
8   angle and said driving property information of said tilt  
9   mirror, both of which are input by said parameter input unit.

1           3. An apparatus as set forth in claim 2, said apparatus  
2 further comprising:

3           a plurality of electrodes arranged for each said tilt  
4 mirror; and

5           a switch that selects, based on said control signal,  
6 one of said plurality of electrodes to which said control  
7 signal is provided.

1           4. An apparatus as set forth in claim 2, wherein said  
2 tilt mirror is an MEMS (Micro Electro Mechanical Systems)  
3 mirror.

1           5. An apparatus as set forth in claim 3, wherein said  
2 tilt mirror is an MEMS (Micro Electro Mechanical Systems)  
3 mirror.

1           6. An apparatus as set forth in claim 1, said apparatus  
2 further comprising:

3           a plurality of electrodes arranged for each said tilt  
4 mirror; and

5           a switch that selects, based on said control signal,  
6 one of said plurality of electrodes to which said control  
7 signal is provided.

1           7. An apparatus as set forth in claim 6, wherein said  
2 tilt mirror is an MEMS (Micro Electro Mechanical Systems)  
3 mirror.

1        8. An apparatus as set forth in claim 1, wherein said  
2 tilt mirror is an MEMS (Micro Electro Mechanical Systems)  
3 mirror.

1        9. A method for controlling tilting of a tilt mirror,  
2 said method comprising the steps of:  
3        producing a control signal, for controlling the tilting  
4 of said mirror, based on a parameter which determines a target  
5 tilt angle of said tilt mirror;  
6        removing a resonance frequency component, which is  
7 caused by movement of said tilt mirror into a desired angle,  
8 from said control signal by a digital filter; and  
9        performing digital square-root calculation so as to  
10 compensate for non-linearity of said control signal.

1        10. An apparatus which controls tilting of a tilt mirror  
2 which is controlled by electrostatic attraction, said  
3 apparatus comprising:  
4        a control signal producing unit which produces a control  
5 signal, for controlling the tilting of said mirror, based  
6 on a parameter that determines a target tilt angle of said  
7 tilt mirror; and  
8        a non-linearity compensation calculating unit which  
9 performs voltage approximate calculation so as to compensate  
10 for non-linearity, in said control signal obtained by said  
11 control signal producing unit, of said tilt angle against  
12 electrostatic capacity of said tilt mirror, a driving signal

13 for driving said tilt mirror being thereby produced.

1 11. An apparatus as set forth in claim 10, wherein said  
2 non-linearity compensation calculating unit includes a  
3 non-linearity compensation calculating table which stores,  
4 as result of such voltage approximate calculation, voltage  
5  $V_d$  of said driving signal given by:

6  
7 
$$V_d = \sqrt{\frac{\theta_{\max}}{V_{C_{\max}}} V_c} / \alpha \left( \frac{\theta_{\max}}{V_{C_{\max}}} V_c \right) \quad \dots \text{ (C-4)}$$

8  
9 where  $V_c$  represents a voltage of said control signal;  $V_{C_{\max}}$   
10 represents a maximal value of the voltage of said control  
11 signal;  $\theta_{\max}$  is a maximal value of said tilt angle.

1 12. An apparatus as set forth in claim 11, wherein said  
2 non-linearity compensation calculating unit further  
3 includes:

4 a gain information storing unit which stores gain  
5 information, one information item for each of said plurality  
6 of tilt mirrors having an identical construction, each said  
7 information item compensating for a spring constant error  
8 of a corresponding one of said plurality tilt mirrors; and

9 a gain adjusting unit which adjusts an output gain of  
10 said non-linearity compensation calculating table based on  
11 said gain information stored in said gain information storing  
12 unit.

1           13. An apparatus as set forth in claim 12, wherein said  
2 control signal producing unit has a digital filter which  
3 removes, from the control signal, a resonance frequency  
4 component caused by movement of said tilt mirror into a desired  
5 angle.

1           14. An apparatus as set forth in claim 12, wherein said  
2 tilt mirror is an MEMS (Micro Electro Mechanical Systems)  
3 mirror.

1           15. An apparatus as set forth in claim 13, wherein said  
2 tilt mirror is an MEMS (Micro Electro Mechanical Systems)  
3 mirror.

1           16. An apparatus as set forth in claim 11, wherein said  
2 control signal producing unit has a digital filter which  
3 removes, from the control signal, a resonance frequency  
4 component caused by movement of said tilt mirror into a desired  
5 angle.

1           17. An apparatus as set forth in claim 16, wherein said  
2 tilt mirror is an MEMS (Micro Electro Mechanical Systems)  
3 mirror.

1           18. An apparatus as set forth in claim 11, wherein said  
2 tilt mirror is an MEMS (Micro Electro Mechanical Systems)  
3 mirror.

1           19. An apparatus as set forth in claim 10, wherein said  
2 control signal producing unit has a digital filter that  
3 removes, from the control signal, a resonance frequency  
4 component, which is caused by movement of said tilt mirror  
5 into a desired angle.

1           20. An apparatus as set forth in claim 19, wherein said  
2 tilt mirror is an MEMS (Micro Electro Mechanical Systems)  
3 mirror.

1           21. An apparatus as set forth in claim 10, wherein said  
2 tilt mirror is an MEMS (Micro Electro Mechanical Systems)  
3 mirror.

1           22. An apparatus as set forth in claim 21, such MEMS  
2 tilt mirror having a comb-shaped electrode to receive said  
3 driving signal.

1           23. A method for controlling tilting of a tilt mirror  
2 which is controlled by electrostatic attraction, said method  
3 comprising the steps of:

4           producing a control signal, for controlling the tilting  
5 of said mirror, based on a parameter which determines a target  
6 tilt angle of said tilt mirror; and

7           performing voltage approximate calculation so as to  
8 compensate for non-linearity, in said control signal obtained  
9 by said control signal producing unit, of said tilt angle

10 against electrostatic capacity of said tilt mirror, a driving  
11 signal for driving said tilt mirror being thereby produced.

1 24. An apparatus which controls tilting of a tilt mirror  
2 which is controlled by electrostatic attraction, said  
3 apparatus comprising:

4 a control signal producing unit which produces a control  
5 signal for controlling the tilting of said mirror; and

6 a pulse waveform compensation unit which controls and  
7 compensates for a pulse waveform that appears in initial  
8 part of the control signal, which is produced by said control  
9 signal producing unit.

1 25. An apparatus as set forth in claim 24, further  
2 comprising a band elimination filter, disposed between said  
3 control signal producing unit and said pulse waveform  
4 compensation unit, which filter removes, from the control  
5 signal, a resonance frequency component caused by movement  
6 of said tilt mirror into a desired angle and produces a step  
7 signal,

8 said pulse waveform compensation unit controlling only  
9 the pulse waveform which appears in the initial part of the  
10 step signal.

1 26. An apparatus as set forth in claim 25, wherein said  
2 band elimination filter is a digital filter.

1           27. An apparatus as set forth in claim 24, wherein said  
2 tilt mirror is an MEMS (Micro Electro Mechanical Systems)  
3 mirror.

1           28. An apparatus as set forth in claim 25, wherein said  
2 tilt mirror is an MEMS (Micro Electro Mechanical Systems)  
3 mirror.

1           29. An apparatus as set forth in claim 26, wherein said  
2 tilt mirror is an MEMS (Micro Electro Mechanical Systems)  
3 mirror.

1           30. A method for controlling tilting of a tilt mirror,  
2 said method comprising the steps of:  
3           producing a control signal for controlling the tilting  
4 of said mirror; and  
5           controlling and compensating for a pulse waveform  
6 appearing in initial part of the control signal which is  
7 produced by said control signal producing unit.